UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 27

HANCOCK COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER
AND L. H. SMITH

URBANA, ILLINOIS, MAY, 1924

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Hancock county was conducted.

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SUPPLEMENT

HANCOCK COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH[1]

LOCATION AND CLIMATE OF HANCOCK COUNTY

Hancock county is located in the extreme western part of the state just north of an east-west line running thru the center of the state. It is a medium-sized county containing 765 square miles.

The climate of Hancock county is apparently modified slightly by the Mississippi river. The greatest range in temperature in any one year from 1896 to 1923 was 129 degrees in 1914. The highest temperature recorded during this period was 108° in 1901; the lowest was –30° in 1905. The average date of the last killing frost in the spring is April 26 and the earliest in the fall is October 8. The average length of the growing season is 168 days. Since 1896 the shortest growing season was 131 days in 1901 and the longest was 190 days in 1914.

The average annual rainfall for the county from 1896 to 1923 was 36.39 inches. The rainfall is well distributed, as is shown by the following figures which give the average rainfall by months for this period: January, 2.41 inches; February, 1.65; March, 2.89; April, 3.16; May, 4.82; June, 4.66; July, 3.80; August, 3.51; September, 4.47; October, 2.03; November, 1.80; December, 1.38.

AGRICULTURAL PRODUCTION

General farming, with live stock an important feature of the farming business, prevails in Hancock county. Owing to rough topography, about 20 percent of the area of the county is better adapted to permanent pasture than to the production of the ordinary farm crops, and much of it is used for this purpose. In 1920, as shown by the Fourteenth Census of the United States, there were 3,463 farms with an average size of 133.5 acres each, 105.7 acres of which were improved. Of these farms, 37.5 percent were operated by tenants, which represents a slight decrease in tenantry during the last twenty years.

The principal crops are corn, oats, wheat, rye, and forage crops, including timothy, clover, mixed clover and timothy, silage crops, and corn cut for forage. The census reports the following acreage and yield for the more important crops for 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	102,612	4,065,339 bu.	39.6 bu.
Oats	50,362	1,865,165 bu.	37.0 bu.
Wheat	60,714	1,216,445 bu.	20.0 bu.
Rye	22,743	303,230 bu.	13.3 bu.
Timothy alone	9,036	11,049 tons	1.22 tons
Timothy and clover mixed	20,981	26,622 tons	1.27 tons
Clover alone	11,010	14,019 tons	1.27 tons
Silage crops	3,379	25,341 tons	7.50 tons
Corn cut for forage	6,144	13,176 tons	2.14 tons

[1]R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

The live-stock interests are important in Hancock county, as is shown by the following figures taken from the 1920 census.

Animals and animal products	*Number*	*Value*
Horses	20,318	$1,783,865
Mules	1,337	161,069
Beef cattle	33,170	1,942,851
Dairy cattle	13,153	880,166
Sheep	11,909	154,902
Swine	96,618	1,778,411
Chickens and other poultry	386,751	384,796
Eggs and chickens	———	1,093,222
Dairy products	———	561,938
Bees	2,622 (hives)	17,893
Honey and wax	37,071 (lbs.)	8,599

Fruit growing is of comparatively little importance in the county, excepting in the case of grapes. In 1919 there were harvested 2,148,662 pounds of grapes, which places this county far in the lead of any other county in the state in grape production. In view of the considerable area of land better adapted to orchards than to field crops, and the favorable climatic conditions of this region, more attention might well be given to the production of orchard fruits, especially of apples.

SOIL FORMATION

The most important period in the geological history of Illinois from the standpoint of soil formation was the Glacial period, during and immediately following which time the materials were deposited from which the soils of the state were later in large part formed. At that time snow and ice accumulated in the region of Labrador and to the west of Hudson Bay in such large amounts that the mass pushed outward from these centers, chiefly southward. In moving across the country from the north, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. As the ice mass pushed along over its bed, an immense amount of rock powder was produced by the grinding or file-like action of the rock material imbedded in the ice. The front of the ice continued to advance until the rate of melting back just balanced the rate of forward movement. During the time when the front of the ice sheet was stationary, that is, when the rate of melting back equaled the rate of advance, the rock material which had been brought forward accumulated in a broad, usually undulating, ridge known as a terminal moraine. When the ice sheet melted more rapidly than the glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered. Such a deposit made as the ice sheet receded is known as a ground moraine.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. They are described as follows, in the order of their occurrence:

(1) The Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the exact area, however,

being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeastern part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

The material transported by the glaciers varied with the character of the rocks over which they passed. Granites, sandstones, limestones, shales, etc., were torn from their lodging places by the enormous denuding power of the ice sheet and ground up together. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds or possibly thousands of feet in thickness. Pre-glacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were entirely changed. The mixture of materials deposited by the glaciers is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated as 115 feet.

Previous to the ice invasion, this region generally was not well suited to agriculture because of its rough and hilly character, as is shown by borings which indicate many preglacial valleys that later were filled with drift. The general effect of the glaciers was to change the surface from hilly to gently undulating. Only a few streams have done much to change the topography, and these in only very limited areas.

THE GLACIATIONS OF HANCOCK COUNTY

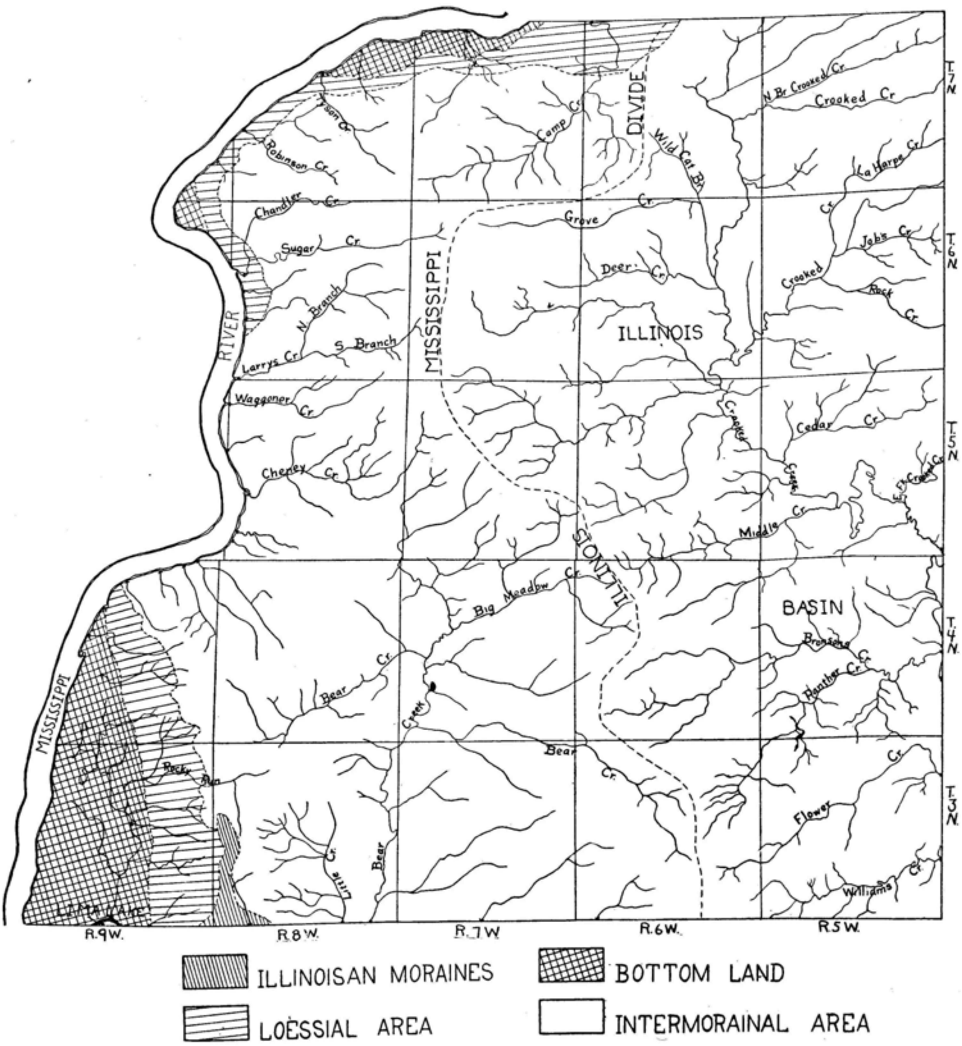
Hancock county was covered in part by the Kansan and entirely by the Illinoisan glacier. It received extensive deposits of glacial drift, yet very little of the present soil has been formed directly from it. Later deposits of rock flour, or loess, buried the drift, so that it is now exposed only in ravines and gullies where erosion has removed the blanket of wind-deposited loess. The extent of the Kansan ice sheet in this state is rather difficult to determine because the Illinoisan drift sheet has buried the Kansan drift to a depth of 20 to 200 feet or more. Before the Glacial period, the region of Hancock county was hilly, as is shown by the presence of drift-filled valleys that have been found in drilling wells. One of these old buried valleys near Carthage was filled to a depth of 214 feet, and there are many others fully as deep. All surface indications of many of these valleys have been completely obliterated.

The only moraine in Hancock county extends southward from Warsaw about two miles from the bluff of the Mississippi river. This ridge extends into Adams county at the south and apparently marks the western limit of the Illinoisan glacial lobe. The drift is mainly a compact material, averaging from 50 to 60 feet in depth, and is covered with a layer of wind-blown material, or loess, varying from 4 to 20 feet in depth. The deeper part of the loess is near the Mississippi bluff, and in places where the adjoining bottom land is widest. The drift is not usually uniform in composition, but contains strata of sand, gravel, and fine material. About four miles south of Hamilton, a peaty soil containing wood was struck at a depth of about 42 feet. This formation probably represents the soil formed on the Kansan drift and later buried by the Illinoisan drift sheet. It is called the Yarmouth soil.

PHYSIOGRAPHY AND DRAINAGE

The valley of the Mississippi river is from 150 to 200 feet below the upland. The altitudes of some places in Hancock county are as follows: Adrian, 705 feet; Augusta, 672; Basco, 650; Bentley, 671; Bowen, 693; Burnside, 665; Carthage, 678; Chile, 670; Colusa, 653; Dallas, 536; Denver, 680; Disco, 671; Durham, 685; Elvaston, 675; Ferris, 685; Hamilton, 515; LaCrosse, 645; LaHarpe, 691; McCall, 699; Nauvoo, 500; Niota, 520; Plymouth, 642; Pontoosuc, 534; Powellton, 683; Sonora, 510; Stillwell, 669; Sutter, 700; Tioga, 700; Warsaw, 490; Webster, 685; West Point, 667.

The highest part of the county is the morainal ridge extending in a north-south direction just west of Tioga. The highest point is in Section 6 of Walker township (Township 3 North, Range 8 West). This point is approximately 765 feet above sea level.



MAP SHOWING THE DRAINAGE BASINS OF HANCOCK COUNTY WITH MORAINAL, INTERMORAINAL, LOESSIAL, AND BOTTOM-LAND AREAS

The county is divided into two principal drainage areas, one of which drains into the Mississippi and the other into the tributaries of the Illinois. The area draining into the Mississippi is about 6 miles wide at the north and 22 miles wide at the south. From the north line of the county to the town of Warsaw, the Mississippi flows in a valley that is but very little wider than the river itself. South of Warsaw the valley widens out until at the south line of the county, the bottom land is about 4 miles wide. Bear creek is the principal stream in Hancock county flowing into the Mississippi river.

The northern half of the Mississippi drainage area has numerous short streams flowing in deep valleys. The upland is rather flat and part of the divide between the Mississippi and the Illinois river is very flat and rather poorly drained. This area is occupied by the soil types Black Clay Loam and Black Silt Loam On Clay. The area along Bear creek in the southern two townships thru which this stream runs is very badly eroded, a great deal of the area being unfit for cultivation. Its only use is for pasture or fruit. The divide between the Mississippi and the Illinois drainage systems in the southern part of the county passes thru Carthage and Bowen. South of Bowen there is an area of flat, poorly drained land that is occupied mainly by Black Silt Loam On Clay.

The eastern part of the county constitutes the other large drainage area. This area is drained by Crooked creek and its tributaries into the Illinois river. This region is badly cut up by numerous streams that flow from McDonough county westward. The bottom land of Crooked creek varies greatly in width. At three places it is contracted to a width but little more than that of the creek itself; it then expands so that it is a mile or more in width. A series of very interesting curves or crooks, that help to give Crooked creek its name, occur in the southeast corner of Hancock township (Township 5 North, Range 5 West).

SOIL MATERIALS AND SOIL TYPES

Altho Hancock county was covered, during the Glacial period, with a deposit of drift ranging from about 20 to over 200 feet deep, this drift forms the present surface only where erosion has been active. By far the largest part of the soil material has been transported and deposited upon the drift by wind, as explained above. This formation, which is called loess, varies from 4 to 25 feet in depth. This deposit seems to have been laid down, in part, at a time immediately following the Illinoisan glaciation, and in part later. This difference in time of deposition is indicated by a mature, well formed subsurface and subsoil over most of the county, indicating age, while in the north-central portion of the county, the subsurface and subsoil development has not progressed very far. This latter area is leached of its carbonate to a less depth than is the case in the former area, which fact also shows a difference in age.

Exclusive of bottom land, there are three general soil areas in Hancock county located as follows: (1) two areas of deep loess along the Mississippi bluff, one in the southwest part of the county about two miles wide extending south from Warsaw, and the other varying in width from one-half to two miles and extending north from Sonora; (2) the comparatively small area in the

TABLE 1.—SOIL TYPES OF HANCOCK COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 800)			
226 526	Brown Silt Loam	255.08	163,252	33.35
528	Brown-Gray Silt Loam On Tight Clay	57.20	36,608	7.48
525.1	Black Silt Loam On Clay	30.56	19,558	4.00
520	Black Clay Loam	1.76	1,126	.23
871	Brown Fine Sandy Loam	.76	486	.10
		345.36	221,029	45.16
	(b) Upland Timber Soils (200, 500, 800)			
234 534	Yellow-Gray Silt Loam	166.24	106,395	21.73
535	Yellow Silt Loam	146.08	93,492	19.10
874	Yellow-Gray Fine Sandy Loam	14.96	9,574	1.96
875	Yellow Fine Sandy Loam	16.08	10,291	2.10
532	Light Gray Silt Loam On Tight Clay	2.68	1,715	.35
		346.04	221,465	45.24
	(c) Terrace Soils (1500)			
1520.5	Black Clay Loam On Rock	.12	77	.02
1560.5	Brown Sandy Loam On Rock	.28	179	.04
		.40	256	.06
	(d) Old Bottom-Land Soils (1300)			
1325	Deep Brown Silt Loam	29.36	18,790	3.84
1354	Mixed Loam	9.28	5,939	1.21
		38.64	24,729	5.05
	(e) Late Bottom-Land Soils (1400)			
1426	Brown Silt Loam	10.88	6,963	1.42
1415	Drab Clay	7.76	4,966	1.01
1460	Brown Sandy Loam	7.88	5,043	1.03
1454	Mixed Loam	2.36	1,510	.31
1475	Yellow Fine Sandy Loam	3.84	2,458	.50
1426.2	Brown Silt Loam On Sand	.40	256	.05
1480	River Sand	.32	205	.04
1415.3	Drab Clay On Sand	.60	384	.08
		34.04	21,785	4.44
	(f) Residual (000)			
099	Rock Outcrop	.16	102	.02
	(g) Miscellaneous			
	Water	.24	154	.03
	Total	764.88	489,523	100.00

north-central part of the county made up of soils having very pervious subsoils; and (3) the balance of the county made up of soils, the subsoils of which are of a more clayey nature, less pervious to water and air. Much of the Brown-Gray Silt Loam On Tight Clay and the Black Silt Loam On Clay are found in this third area. Even in the case of the timber types, the subsoils are less pervious than they are usually found to be in the latitude of Hancock county.

The various types of soils of the county as determined by the suvery are classified into six groups as follows:

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with forests and in which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) *Upland Timber Soils,* including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) *Terrace Soils,* including bench lands or second bottom lands formed by deposits from overloaded streams.

(d) *Old Bottom-Land Soils,* including the low-lying land along streams other than the Mississippi river and formed of older materials than those of the late bottom lands.

(e) *Late Bottom-Land Soils,* including the bottom lands of the Mississippi river and representing a newer formation than the old bottom lands.

(f) *Residual,* including rock outcrop.

Table 1 gives a list of the soil types found in Hancock county, classified according to the groups described above. It also shows the area of each type in square miles and in acres and its percentage of the total area of the county. For example, it will be observed that 45.16 percent of the area consists of upland prairie soil, 45.24 percent of upland timber soil, .06 percent of terrace soil, 5.05 percent of old bottom-land soils, and 4.44 percent of late bottom-land soils.

The accompanying maps show the location and boundary lines of every type of soil in the county, even down to areas of a few acres in extent.

For explanations concerning the classification of soils and the interpretation of the maps and tables, the reader is referred to the first part of the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN HANCOCK COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose, samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2,000,000 pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and the distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling, we have represented separately three zones for plant feeding. The upper, or surface layer includes at least as much soil as is ordi-

narily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation from their insoluble forms is governed by many factors.

For convenience in making application of the chemical analyses the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2,000,000 pounds. It is understood, of course, that this value is only an approximation, but it is believed that, with this understanding, it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amount of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in two million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Hancock county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity in the different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types. In examining each soil type, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping. Therefore, it is often desirable to determine the lime requirement for a given field, as explained in the Appendix, page 32.

In connection with Table 2, it is of interest to note the variation among the different soil types with respect to their content of the various plant-food elements. It will be seen from the analyses that in all the soil types the amount of nitrogen is a little less than $\frac{1}{10}$ that of total organic carbon, which is used as an index of the organic-matter content of the soil. This constant proportion is an indication of the close association of nitrogen with the organic matter of the soil. This consistent relationship is not to be observed between any of the other elements. The organic matter with its nitrogen varies widely in amount in the different soils of the county. The highest content of organic carbon, 72,200 pounds per acre, was found in the Black Clay Loam On Rock in the Mississippi terrace, and this soil also contained the highest amount of nitrogen, 5,820 pounds per acre. The sand soil in the Mississippi bottom, on the other hand, contained the smallest amounts of both organic carbon and nitrogen, the respective amounts being 11,200 and 640 pounds per acre. It is of interest

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF HANCOCK COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown Silt Loam........	49 650	3 940	1 010	630	31 820	7 630	10 730
528	Brown-Gray Silt Loam On Tight Clay.........	43 470	3 550	870	680	31 190	6 380	9 330
525.1	Black Silt Loam On Clay	69 290	5 380	1 380	690	28 930	11 360	16 970
520	Black Clay Loam	46 940	5 340	1 760	1 180	29 960	13 720	18 060
871	Brown Fine Sandy Loam	49 660	3 960	1 220	720	32 320	8 720	12 880
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-Gray Silt Loam ..	28 500	2 450	800	490	32 850	6 140	8 070
535	Yellow Silt Loam	25 920	2 320	770	360	33 500	6 230	7 670
874	Yellow-Gray Fine Sandy Loam.................	28 680	2 550	1 010	510	34 310	6 180	10 280
875	Yellow Fine Sandy Loam	19 040	1 880	620	420	34 100	5 940	10 600
532	Light Gray Silt Loam On Tight Clay............	21 460	2 040	660	440	32 640	5 200	10 220
	(c) Terrace Soils (1500)							
1520.5	Black Clay Loam On Rock	72 200	5 820	1 480	1 180	21 400	8 300	17 320
1560.5	Brown Sandy Loam On Rock	47 940	4 180	1 300	800	23 740	6 000	10 620
	(d) Old Swamp and Bottom-Land Soils (1300)							
1326	Deep Brown Silt Loam..	31 620	2 500	960	340	32 740	8 000	11 660
1354	Mixed Loam[1]...........							
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam........	45 840	3 840	2 180	660	31 100	10 500	14 840
1415	Drab Clay.............	42 200	3 380	1 760	740	35 100	13 980	15 320
1460	Brown Sandy Loam	32 260	2 980	1 460	580	31 080	8 820	14 620
1475	Yellow Fine Sandy Loam.	29 480	2 560	1 320	480	29 360	7 440	17 740
1426.2	Brown Silt Loam On Sand	42 160	3 720	1 720	680	32 900	11 400	15 120
1480	River Sand.............	11 200	640	700	280	19 700	2 720	8 180
1415.3	Drab Clay On Sand.....	51 740	4 840	1 800	960	33 680	14 420	16 360

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

further to note the relatively larger amounts of organic carbon and nitrogen in the upland prairie soils as compared with the upland timber soils. The five prairie soil types in the county contain, as an average, 50,800 pounds per acre of organic carbon and 4,400 pounds of nitrogen. The five timber soil types average about half as much, or 24,600 pounds and 2,200 pounds of the two elements respectively. The relative deficiency of the timber soils in the total amounts of these important elements serves to emphasize the necessity of giving

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF HANCOCK COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226 526	Brown Silt Loam........	64 670	5 150	1 630	900	64 540	18 700	20 150
528	Brown-Gray Silt Loam On Tight Clay............	47 020	3 860	1 320	670	64 120	16 490	17 540
525.1	Black Silt Loam On Clay	82 160	6 440	2 150	1 280	58 120	25 290	36 490
520	Black Clay Loam	85 440	7 040	3 280	880	58 040	29 640	43 240
871	Brown Fine Sandy Loam	63 720	5 440	1 960	1 160	63 720	20 720	24 960
	(b) Upland Timber Soils (200, 500, 800)							
234 534	Yellow-Gray Silt Loam ..	21 790	2 210	1 440	690	66 880	19 700	8 070
535	Yellow Silt Loam	18 270	2 150	1 440	760	69 110	19 240	14 400
874	Yellow-Gray Fine Sandy Loam................	23 920	2 300	1 540	840	71 360	16 240	18 340
875	Yellow Fine Sandy Loam	12 240	1 640	1 640	640	68 000	22 720	22 760
532	Light Gray Silt Loam On Tight Clay............	22 880	2 080	1 200	480	65 400	15 600	20 320
	(c) Terrace Soils (1500)							
1520.5	Black Clay Loam On Rock	90 560	6 840	2 080	1 880	46 040	18 760	35 280
1560.5	Brown Sandy Loam On Rock.................	77 160	6 680	2 360	1 560	47 720	11 880	22 240
	(d) Old Swamp and Bottom-Land Soils (1300)							
1326	Deep Brown Silt Loam ..	62 320	5 080	2 200	600	66 600	16 520	21 760
1354	Mixed Loam[1]..........							
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam........	52 520	4 440	2 640	1 240	60 160	17 680	28 680
1415	Drab Clay	63 240	4 600	3 240	1 480	69 680	29 480	31 640
1460	Brown Sandy Loam.....	38 200	3 560	2 240	760	59 560	15 600	26 520
1475	Yellow Fine Sandy Loam	46 800	4 080	2 160	880	57 200	16 240	38 040
1426.2	Brown Silt Loam On Sand	24 840	2 080	2 040	640	53 840	15 240	23 160
1480	River Sand.............	11 920	760	1 240	440	42 640	6 400	19 000
1415.3	Drab Clay On Sand.....	53 280	5 080	2 120	1 280	60 160	21 000	31 280

LIMESTONE AND SOIL ACIDITY.—See note in Table 2

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

particular attention to the return of organic materials to soils of this group in planning crop rotations. Other elements are not so closely associated with each other as are nitrogen and organic matter, altho there is a rather high correlation between the sulfur content and the amount of organic matter and nitrogen. Otherwise the elements vary independently and within a fairly wide range as a rule. Thus the phosphorus content varies from 620 pounds per acre in Yellow Fine Sandy Loam to 2,180 pounds in Brown Silt Loam, Bottom. Magnesium ranges from 2,720 pounds in River Sand to a maximum of 14,420 pounds in Drab Clay On Sand, while total calcium ranges from 7,670 to 18,060 pounds per acre. The potassium content of all the soils is fairly constant at about

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF HANCOCK COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown Silt Loam	37 530	3 560	2 360	980	93 980	42 450	35 040
528	Brown-Gray Silt Loam On Tight Clay	36 870	3 600	2 370	770	90 160	43 340	32 230
525.1	Black Silt Loam On Clay	58 580	4 260	2 760	840	89 680	40 880	46 260
520	Black Clay Loam	52 740	4 320	3 480	660	91 140	40 680	89 580
871	Brown Fine Sandy Loam	27 420	3 120	2 760	900	98 280	43 980	43 080
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-Gray Silt Loam	20 190	2 480	2 990	850	97 430	43 600	27 700
535	Yellow Silt Loam	16 320	2 180	3 140	880	96 640	39 020	24 820
874	Yellow-Gray Fine Sandy Loam	23 790	2 280	3 270	960	102 810	39 360	30 270
875	Yellow Fine Sandy Loam	10 620	1 740	3 720	480	102 960	40 020	40 080
532	Light Gray Silt Loam On Tight Clay	18 540	2 280	3 120	540	91 500	41 520	34 380
	(c) Terrace Soils (1500)							
1520.5	Black Clay Loam On Rock[1]							
1560.5	Brown Sandy Loam On Rock[1]							
	(d) Old Swamp and Bottom-Land Soils (1300)							
1326	Deep Brown Silt Loam	47 400	4 500	3 360	600	98 820	23 880	26 460
1354	Mixed Loam[2]							
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam	43 380	3 600	3 240	1 080	89 940	25 260	41 580
1415	Drab Clay	70 200	5 400	4 500	1 860	102 720	44 880	48 180
1460	Brown Sandy Loam	17 040	900	2 160	600	71 400	15 120	32 580
1475	Yellow Fine Sandy Loam	83 340	7 260	3 720	1 380	91 860	23 100	46 680
1426.2	Brown Silt Loam On Sand	11 820	720	2 160	840	63 120	11 760	29 520
1480	River Sand	19 440	1 080	1 920	660	67 620	11 640	29 280
1415.3	Drab Clay On Sand	22 920	1 200	2 940	180	67 620	13 860	29 520

LIMESTONE AND SOIL ACIDITY.—See note in Table 2

[1]No samples were taken because this stratum is rock. [2]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

30,000 pounds per acre, with only three significant variations, namely, the two soils on the terrace and the River Sand. The amount of total potassium present is far in excess of maximum crop requirements. The only important soil type which is characteristically deficient in total potassium is Peat, a type not represented in Hancock county.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded in a similar manner the amounts of the plant-food elements in the middle and lower sampling strata. It is frequently of interest to know the total supply of plant-food elements accessible to the

growing crops. While it is impracticable to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that the bulk of the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

A wide range of variation with respect to composition is found to occur in the sub-layers as well as in the top layer of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. For example, in the most extensive upland prairie type in the county, Brown Silt Loam, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 12,650 pounds. This is about the amount of nitrogen contained in 12,600 bushels of corn. The amount of phosphorus, 5,000 pounds, contained in the same soil is equivalent to that contained in 22,000 bushels of corn, while in the same quantity of this soil there is present 190,340 pounds of potassium, the equivalent of that contained in 1 million bushels of corn. The most extensive upland timber soil in the county, Yellow-Gray Silt Loam, contains in the entire 40-inch stratum, approximately 7,000 pounds per acre of nitrogen, an amount equal to that in 7,000 bushels of corn, while the amounts of phosphorus and potassium in the same quantity of this soil are essentially the same as in the Brown Silt Loam.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration aside from the mere amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon and in this way these chemical data contribute fundamental information for the planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Hancock county occupy 345.36 square miles, or somewhat less than half of the area of the county. They vary from black to light brown or grayish brown in color in the surface, owing to the variation in amount and condition of the organic matter. The prairie soils of the county, with the exception of those found in the north-central portion, chiefly in Durham township (Township 7 North, Range 6 West), have a tendency towards compactness in the subsoil. This character is not sufficiently developed to interfere

with water and root penetration excepting in the areas mapped as Brown-Gray Silt Loam On Tight Clay. The plastic and impervious nature of the subsoil of this type makes successful underdrainage difficult, or even impossible, in areas where the impervious condition is most highly developed. This very striking difference in the perviousness of the soils in the extreme northern portion of the county compared with those in the middle and southern portions, is probably to be explained by difference in age and origin of the soil material. Most of the material which forms the soil in the extreme northern part of the county came from the north, while that which is distributed over the rest of the county is wind-blown material derived from sediments brought down by the Des Moines river from the Kansan drift sheet. This latter material was low in, or devoid of, lime, and appears to have been finer in texture than the sediments brought down from the north, which were derived from the Iowan glaciation.

The dark color of the prairie soils is due to the accumulation of organic matter, which is derived very largely from the roots of prairie grasses. The network of grass roots was protected from rapid and complete decay by the protective covering of fine, moist, soil material and by the mat of vegetative material formed by old grass stems and leaves, which was very effective in excluding the oxygen of the air. On the native prairies the stems and leaves of the grasses were usually burned in part or disappeared in part thru decay, so that they actually added little organic material to the soil; however, the protection afforded by this mat of decaying material was of importance in retarding the decay of the roots. From a sample of virgin sod of bluestem, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Silt Loam (226, 526)

Brown Silt Loam is the most extensive soil type in Hancock county. It covers an area of 255.08 square miles, or just about one-third of the area of the county. The difference in the origin of the soil material in the northern and southern parts of the county has resulted in two phases of Brown Silt Loam, one, found in the northern part of the county, having a silty, friable, indistinctly developed subsoil, and the other, found in the central and southern parts of the county, having a well-developed, clayey subsoil. A very small area of the morainal type (226) occurs in the southwestern part of the county just west of Tioga, in the form of a distinct north-south ridge.

There are small areas in the county which are mapped as Brown Silt Loam that have been recently invaded by forests; the invasion, however, has not been of sufficient duration to materially change the character of the soil. These forests generally consist of black walnut, wild cherry, hackberry, ash, hard maple, elm, and bur oak.

The surface soil of this type is a brown silt loam, usually with a grayish cast, and varies in depth from 8 to 16 inches. As the type approaches Brown-Gray Silt Loam On Tight Clay, the grayish cast becomes more pronounced, and where it approaches timber soils, the color becomes a yellowish brown. As a rule, the fine sand content increases as the river is approached. The subsurface is usually a yellowish or grayish brown, friable, silt loam, ranging from 6 to 18 inches in thickness. The subsoil to a depth of 35 to 40 inches is a mottled,

yellowish brown, or yellowish drab, fairly compact clay or silty clay, excepting in Durham township and vicinity, where it is a mottled, yellowish gray, friable silt loam. The organic-matter content of this type ranges from an amount that would be considered low for the type on the more rolling areas and near the timber soil areas, to a fair amount on the flat, more poorly drained areas.

Management.—This type is in fair physical condition. However, cropping practices which do not make provision for systematic and adequate additions of organic matter to the soil are gradually resulting in an increasingly poor physical condition. The type is acid, with the possible exception of a few areas, tho not strongly so. Results from the Carthage experiment field (see page 50) show that the use of limestone on this type is very profitable. Its use, moreover, makes the growth of alfalfa and sweet clover possible. Both of these crops are excellent in helping to keep the soil in good condition. The first application of limestone usually should be at the rate of 1 to 3 tons per acre. It is suggested that the exact rate of application be determined in consultation with the county farm adviser, or by correspondence with the Agricultural Experiment Station.

The evidence regarding the use of phosphates is not of such a nature that any definite recommendations can be made for this type in Hancock county. The use of rock phosphate on the Carthage field has resulted in an increase in the average yield of all crops, but the increases have not been large enough in either the grain or the live-stock system to pay for the phosphate. On a similar soil at Urbana (see page 48) with a corn, oats, clover, wheat rotation, rock phosphate has been used with excellent results in both the live-stock and the grain systems of farming after the second rotation. It is suggested that a trial be made of rock phosphate, at the rate of ½ ton per acre, for wheat, to be followed by clover. The large returns from the use of steamed bone meal on the Bloomington experiment field, which is located on a similar soil, suggest that, after the nitrogen deficiency has been taken care of, a more available phosphate, either steamed bone meal or acid phosphate, may be used at a profit (see page 55). If either of these phosphates is used, it should be drilled or otherwise well worked into the seed bed, as it is being prepared for wheat, at the rate of about 250 pounds of bone meal or 500 pounds of acid phosphate per acre. When used in these amounts, sufficient phosphorus will be added to the soil to maintain its phosphorus content, if all the hay grown and all the crop residues produced are returned to the soil, either directly or in the form of manure.

Brown-Gray Silt Loam On Tight Clay (528)

Brown-Gray Silt Loam On Tight Clay occurs in irregular and widely distributed areas in the southern two-thirds of the county. It comprizes 57.2 square miles, or 7.48 percent of the area of the county.

The surface soil, to a depth of 8 to 10 inches, is a brown or grayish brown silt loam. The organic-matter content varies as the type merges into other types, being greater where it approaches Brown Silt Loam (526) or Black Silt Loam On Clay (525.1) and less where it grades toward Yellow-Gray Silt Loam (534). The subsurface usually consists of two strata. The upper one to a depth of 15 to 17 inches is a gray or brownish gray silt loam which passes into a yellowish

gray, silty clay loam. This latter stratum passes into a very plastic clay subsoil, which varies greatly in color, but is usually a mottled, yellowish drab or brown, at 16 to 22 inches in depth. The heavy clay subsoil extends to a depth of 40 to 46 inches.

Management.—The flat topography and tight clay subsoil of this type make the drainage poor. Tile, in order to work efficiently, must be placed closer together than in soils having a more open subsoil. The strings should not be over 5 rods apart, and 3 or 4 rods would be better. This type is not strongly acid and ordinarily 2 tons of limestone per acre is sufficient to grow sweet clover. There is some variation, however, in the need for lime, depending upon the depth to which the acidity extends. Care should be taken to provide for frequent additions of fresh organic matter, particularly clovers. Sweet clover excels all others for increasing the producing power of this type of soil. The phosphorus content of this type is slightly less than that of Brown Silt Loam. While satisfactory experimental evidence is lacking regarding the use of phosphate on this soil type, yet a conservative statement would seem to be that rock phosphate at the rate of 1,000 pounds per acre, steamed bone meal at the rate of 150 pounds per acre, or acid phosphate at the rate of 300 pounds per acre used in the rotation on wheat to be followed by clover, would prove a profitable investment unless good applications of manure are being made, in which case it is doubtful whether the phosphates would cause sufficient increases in yield to pay for their cost. Bone meal and acid phosphate when used at the above rates will probably maintain the supply of phosphorus if all the organic materials are returned either directly or in the form of manure, and the use of rock phosphate at the above rate will result in a relatively rapid increase of phosphorus in the soil.

Black Silt Loam On Clay (525.1)

Black Silt Loam On Clay is widely distributed thruout the county and occurs chiefly in association with Brown-Gray Silt Loam On Tight Clay (528). It covers an area of 30.56 square miles, or 4 percent of the area of the county. In topography it is usually flat and the drainage is poor. The presence of the clay subsoil makes it more difficult to underdrain than either Brown Silt Loam or Black Clay Loam. This is especially true where it approaches Brown-Gray Silt Loam On Tight Clay (528).

The surface soil extending to a depth of about 10 inches, is black silt loam. It is well supplied with organic matter, and when well drained, is not difficult to keep in good tilth. It should be realized, however, that provision should be made for returning fresh organic matter at frequent intervals for it is much easier to keep this type in good physical condition than to restore it when once destroyed. The subsurface stratum varies from 8 to 14 inches in thickness. In color it varies from drabbish black to dark drabbish brown with a yellowish tint becoming evident near the bottom of the stratum. The subsoil begins at 17 to 24 inches, and is a plastic drab clay, strongly mottled with grayish yellow. It is inclined to be somewhat impervious.

Management.—Drainage is the first requirement of this type. For maintaining good tilth it is necessary to make systematic provision for adding fresh organic matter. In order to do this, a proper rotation of crops, which includes

clover, should be established, and the crop residues, together with one of the clover crops, should be turned under. In a live-stock system, manure will be an important source of organic matter, and the best possible use should be made of it. This will not only help in maintaining good tilth, but will also help conserve nitrogen and other elements of plant food. This type usually is not acid, and limestone is not advised unless careful tests, or observed failure of the clovers, show where the exceptions to the general rule occur.

Black Clay Loam (520)

Black Clay Loam is frequently called "gumbo" because of its sticky character. Its formation in the low places is due to the accumulation of organic matter and the washing in of clay and fine silt from the slightly higher adjoining lands. The type covers an area of 1.76 square miles. It occurs principally in Rock Creek township (Township 6 North, Range 7 West).

The surface soil extends to a depth of 8 to 12 inches and is a black, granular clay loam with an unusually low organic-matter content for this type of soil. The subsurface, 10 to 16 inches in thickness, is a drab or yellowish drab clay loam. It is pervious to water and is subject to a great deal of shrinkage in times of drouth. The subsoil is usually either a mottled drab or a mottled dull yellow clay or clay loam. As a rule the iron is not highly oxidized because of poor drainage. The checking and jointing in the sub-soil make it readily permeable to water and consequently rather easy to drain. The subsoil often contains a considerable amount of limestone in the form of concretions.

Management.—This type is well supplied with all the elements of plant food and is usually not acid. The important considerations in its management are: first, drainage; and second, provision for maintaining the nitrogen supply and organic-matter content by plowing down crop residues, and manure, and growing clovers. The high clay content of this soil makes it much more difficult to work than is the case with lighter soils and it is much more likely to get into such a condition that an excessive amount of tillage is required to form a good seed bed. The only way to avoid this danger is to keep up the organic-matter supply and to use care in all tillage operations.

Brown Fine Sandy Loam (871)

Brown Fine Sandy Loam occurs in the north-central and southwestern parts of the county.

The surface soil, which is about 8 inches deep, is brown fine sandy loam. It is fairly well supplied with organic matter. The subsurface is 8 to 14 inches in thickness and is yellowish gray fine sandy loam, becoming yellower with increasing depth. The subsoil is mottled yellow silt loam or clayey silt which is fairly compact and yet is pervious to roots and water.

Management.—This type, altho small in area, is an excellent soil. The nitrogen content is about the same as that of Brown Silt Loam, while the phosphorus content is slightly higher than is found in that type. Its management, however, should be practically the same as that recommended for Brown Silt Loam (see page 13).

(b) UPLAND TIMBER SOILS

The upland timber soils occur along streams and are characterized by a yellow, yellowish gray, or gray color, due to their low organic-matter content resulting from the long-continued growth of forest trees.

Yellow-Gray Silt Loam (234, 534)

Yellow-Gray Silt Loam occurs in the outer timber belts along streams. It is well distributed thruout the county, and covers an area of 166.24 square miles, or about one-fifth of the total area of the county. In topography, it is sufficiently rolling for good surface drainage without much tendency to wash if proper care is taken.

The surface soil is about 8 inches deep. It is a brownish gray, yellowish gray, or gray silt loam, having a floury feel. The more nearly level areas are gray in color, while the more rolling areas have a yellowish gray or brownish gray color. As the type approaches Brown Silt Loam or Brown-Gray Silt Loam On Tight Clay, it becomes decidedly darker. The organic-matter content varies considerably, but is low, as is always the case with timber soils in this region. The subsurface varies from 3 to 10 inches in thickness. It is a mottled gray, yellowish gray, or yellowish brown silt loam. The subsoil, extending to a depth of 17 to 36 inches, is a mottled yellow or grayish yellow clay loam, plastic when wet and rather impervious to water.

Management.—The first essential in the management of this type is limestone. Three to four tons of limestone per acre will probably be required for successful sweet clover growth. The second essential is to increase the nitrogen and organic-matter content of the soil. If a good rotation is adopted following the application of limestone, and full use is made of green manures, legume and other residues, and stable manure, this soil will respond by yielding very satisfactory crops, its tilth will be improved, and the tendency to wash on the more rolling areas will be lessened. The merits of sweet clover for use on this type are well known. A three-year rotation which includes sweet clover is excellent. Such a rotation might be corn, oats or soybeans, and wheat seeded with sweet clover. The sweet clover should be plowed down in the spring for corn. The surface soil of this type is somewhat lower in phosphorus than is Brown Silt Loam, the corresponding prairie type. However, the phosphorus content to a depth of 40 inches is as great as, or slightly greater than, that of Brown Silt Loam. Experiments at Raleigh, in Saline county, on soil which is very similar to much of this type as mapped in Hancock county indicate that it is very doubtful whether rock phosphate can be used at a profit. The crop increases following its use have been either very small or entirely lacking. Experiments with steamed bone meal on this type at Antioch in Lake county have shown a good profit from its use. The soil on the Antioch field, while mapped as Yellow-Gray Silt Loam, is somewhat different from this type as mapped in Hancock county; therefore considerable caution should be used in applying the Antioch field results to this type of soil in Hancock county. The well known response of wheat to available phosphates and of corn to potash salts on soils of this general character suggests that, in an experimental way in a rotation including these

crops, potassium chlorid or sulfate at the rate of 75 to 100 pounds per acre be applied at the time of, or immediately prior to, planting corn, unless manure has been applied to the corn ground; and that either acid phosphate at the rate of about 300 pounds per acre, or steamed bone meal at the rate of about 150 pounds per acre, be drilled in at the time of seeding wheat or broadcasted and well worked into the seed bed prior to drilling in the wheat. These suggestions presuppose that good soil management methods are being practiced, including the use of legumes, preferably sweet clover at least during the early period of the soil improvement program, and the return of all organic residues to the soil either directly or in the form of manure.

Results from the Raleigh and Antioch experiments may be found on page 57 of the Supplement.

Yellow Silt Loam (535)

In area, Yellow Silt Loam stands third among the soil types of Hancock county. It covers 146.08 square miles, or practically one-fifth of the area of the county. This type comprizes the hilly land, some of which is badly eroded, and all of which is subject to serious erosion, in the inner timber belt along streams, and is about as widely distributed as Yellow-Gray Silt Loam. It occurs frequently in narrow irregular strips with Yellow-Gray Silt Loam intervening. In most places it is so hilly that it should not be cultivated because of the danger of injury from washing.

The surface soil is a yellow or yellowish gray silt loam, pulverulent and mealy. It varies greatly in depth, owing to differences in the amount of soil removed by erosion. In some places the subsoil is exposed, while in others the surface is 7 or 8 inches deep. The organic-matter content is low, particularly where erosion, either sheet washing or gullying, is now active. The subsurface, where such a stratum is present, is a yellow silty clay loam and it varies in thickness from 0 to about 12 inches. The variation is due to the removal of all or part of the surface and subsurface by washing, which has resulted either in the exposure of the glacial till, or in its occurrence at varying depths below the surface. The subsoil is a compact, yellow clay.

Management.—In the management of Yellow Silt Loam, the most important consideration is that of preventing washing and gullying. Probably the best method of preventing washing is to leave the land in permanent bluegrass or in sweet clover pasture. If the land is cropped at all, a rotation should be practiced that will require a cultivated crop as little as possible, and allow pasture and meadow most of the time. Deep contour plowing should be practiced, and the planting and cultivating should be done on contours. Furrows should not be made up and down the slope. On much of this land the erosion problem may be solved by terracing. Every means should be employed to maintain and increase the organic-matter content of the soil. This will help in holding the soil and in keeping it in good physical condition so that it will absorb a larger amount of water and thus diminish the run-off.

Sweet clover is one of the best plants to grow on rolling land. It provides an abundance of excellent pasture and furnishes a large amount of nitrogen,

thus encouraging a more luxuriant growth of bluegrass. Cover crops should be kept on the land as much as possible. If gullies form, they should be filled with brush or straw to catch the sediment and prevent them from becoming deeper. Gullied land can be reclaimed by filling in the gullies with the plow and scraper, applying about 4 tons of crushed limestone per acre, and seeding to sweet clover. This should be done in the spring. The amount of work and cost involved in such a project should be carefully considered before attempting it. It should also be realized that constant watchfulness and the timely use of straw or cornstalks are necessary to prevent a recurrence of the eroded condition. (See Bulletin 207, Washing of Soils and Methods of Prevention.) In making plans for this rather extensive reclamation work terracing should be carefully considered. For methods of improving Yellow Silt Loam, see the discussion of the Vienna experiment field on page 60 of the Supplement.

Yellow-Gray Fine Sandy Loam (874)

Yellow-Gray Fine Sandy Loam is made up of the coarser material deposited by the wind near the bluff of the Mississippi bottoms. This type contains a large amount of very fine sand. It occupies a strip one to two miles wide on the bluff of the river. It cuts out near Warsaw and does not begin again until six miles north of Hamilton. It is generally true that along the Mississippi where the bottom land becomes very narrow, this wind deposit of deep loess is very narrow, and such is the case in Hancock county. This type occupies 14.96 square miles, or about 2 percent of the area of the county.

The surface soil, which is about 10 inches deep, is a grayish yellow fine sandy loam. The organic-matter content is low, particularly where recent erosion has removed some of the surface soil. The subsurface varies from 6 to 12 inches in thickness, and consists of a mottled, yellowish gray fine sandy silt loam that becomes slightly heavier with increasing depth. The subsoil to a depth of 35 to 40 inches, is a mottled, yellow, silty clay loam, rather compact, but pervious. When it becomes dry it is very difficult to penetrate. At depths of 35 to 40 inches, a friable silt loam is encountered. This material is mottled drab in color and contains numerous yellow spots.

Management.—In the management of Yellow-Gray Fine Sandy Loam, the most important consideration is the increase of the organic-matter content. This is necessary in order to supply nitrogen and to liberate mineral plant food, as well as to give better tilth, to lessen the tendency to run together, to increase the power of the soil for absorbing moisture, and on some of the more rolling phases, to lessen washing. A systematic rotation should be practiced in which legumes are grown every two or three years, primarily for soil improvement. The legumes and crop residues should be turned under either directly or as manure.

The nitrogen content is low. The rotation that is practiced should be planned with a view to supplying this element which is now the limiting factor in crop yields. Sweet clover could be grown with very great profit on this type, for this purpose, especially if the seed alone is taken off and all of the growth turned under, or if it is turned under for corn in the spring of the second year.

This type is acid and contains no carbonates in the deeper subsoil. About 3 tons of limestone per acre should be applied with subsequent applications of about 2 tons per acre as needed.

The supply of phosphorus is very satisfactory and the type is rich in potassium. This is a good alfalfa soil and after the nitrogen and organic-matter supplies have been increased following the application of limestone, it becomes a productive soil for any of the ordinary field crops.

Yellow Fine Sandy Loam (875)

Yellow Fine Sandy Loam occurs adjacent to the Mississippi bottom, and occupies the hilly and very rolling land. This type is so badly broken that but little of it can be cultivated at a profit. The areas of this type are very irregular, consisting of arms extending out into the upland along the creeks and gullies. It is of very little value except for pasture. The type covers 16.08 square miles, or about 2 percent of the area of the county.

The character of the surface, subsurface, and subsoil varies greatly because erosion is more active in some places than in others. The fine sandy loam or deep loess varies from 4 to 40 or more feet in depth. It is acid to a depth of 4 to 15 feet. The color of the surface is usually a reddish yellow. The subsoil at a depth of about 20 inches is a compact, slightly mottled, grayish yellow fine sandy silt loam. In places where erosion is removing the soil material rapidly, this compact subsoil stratum is not found.

Management.—The rough, broken topography of this type makes it inadvisable to attempt to cultivate it. It should be kept in permanent pasture or in timber.

Light Gray Silt Loam On Tight Clay (532)

Light Gray Silt Loam On Tight Clay occupies 2.68 square miles, or .35 percent of the area of the county. It occurs in small isolated areas scattered thruout the county, principally on the divides. The topography is very flat and rather poorly drained, altho not swampy.

The surface soil to a depth of about 7 inches, is a light brownish gray silt loam. In the virgin condition, the surface one or two inches contains enough organic matter to give it a brown color, but beneath this the soil is white and almost devoid of organic matter. Small, rounded, black iron concretions, varying from the size of a mustard seed to that of a pea, are usually present. The organic-matter content is very low. The subsurface is a gray to light gray, very silty material varying from 10 to 12 inches in thickness. It passes abruptly into the subsoil which is a mottled, drab or dull yellow clay. This stratum is very impervious to both air and water.

Management.—This type is very low in organic matter and is more acid than adjoining types. The soil runs together badly, and does not retain moisture well. In the management of the type, ground limestone should be used at the rate of about 4 tons per acre. The phosphorus content is low in the surface soil. However, the physical condition of this type is so poor and the nitrogen content is so low that it is not likely that phosphates could be used at a profit. The use of rock phosphate on the Sparta field, which is located on this type of

soil, has not resulted in increased yields. The use of limestone and residues or manure has given good increases. All crop residues should be turned under directly or in manure, and sweet clover should be grown and practically the entire crop, with the exception of the seed, turned back into the soil. All available farm manure should be put on the land with the least possible loss. Pasturing is one of the best uses that can be made of this land, especially if seeded to sweet clover.

(c) TERRACE SOILS

The terrace soils occur in the sharp bend of the Mississippi river at Nauvoo. At one time the Mississippi flowed at a higher level than at present, but when its course was changed, a ledge of rock was left above the river sufficiently high so that this does not overflow. A layer of soil material has been formed on the rock thru deposition by water and wind, and this now constitutes the terrace soil. It is not a terrace of the ordinary method of formation, but it represents a shelf considerably below the upland.

Black Clay Loam On Rock (1520.5)

Black Clay Loam On Rock covers an area of only 77 acres. It is of very little value from an agricultural standpoint. It consists of black clay loam resting on rock at a depth of 16 to 24 inches.

Brown Sandy Loam On Rock (1560.5)

Brown Sandy Loam On Rock occurs at a slightly higher level than the Black Clay Loam On Rock. It covers an area of only 179 acres and is located in the same region as the preceding type. It is of no great importance from an agricultural standpoint. The soil consists of a dark brown sandy loam resting on rock at a depth of 18 to 26 inches.

(d) OLD SWAMP AND BOTTOM-LAND SOILS

The Illinoisan is one of the oldest glaciations in the state, and the bottom lands within its borders are mapped as old bottoms. The age or maturity of these bottoms is indicated in some places by the character of the soil. In some small areas rather tight clay subsoils have been developed, but this is true only occasionally. A distinct surface, subsurface, and subsoil development is, however, rarely found in bottom-land soils. Altho the bottom lands in Hancock county are somewhat variable, they are mostly silt loams, with the exception of those in the south-central and north-central parts of the county.

Deep Brown Silt Loam (1326)

Deep Brown Silt Loam is widely distributed along the streams and comprizes a very large part of the bottom lands in the eastern part of the county. It occurs as narrow strips in the bottoms of the valleys, varying from a few rods to a mile or more in width. It covers altogether an area of 29.36 square miles, or 3.84 percent of the area of the county.

The surface soil is a brown to light brown silt loam with a medium organic-matter content. There is a gradual change to a clayey silt loam beginning at 10 to 14 inches in depth. The color also changes gradually to a drabbish brown between about 12 and 22 inches, and then becomes a mottled, yellowish brown.

Management.—The chief points to be kept in mind in the management of this type other than good tillage, are the addition of 1 to 2 tons of limestone per acre and the growth of legumes to increase the nitrogen content of the soil, which is low. It is not likely that phosphates of any kind could be used at a profit because of the depth to which plant roots are able to penetrate on this type.

Mixed Loam (1354)

Mixed Loam is confined to the bottom lands of the north-central and south-central parts of the county. Bottom lands which are mapped as this type are so variable that it is not possible to separate out and map the various types which actually occur. They are, therefore, grouped together and called Mixed Loam. In texture the surface soil of this type varies from sand to silty clay loam, and in color from black to light brown with occasional small areas having a gray tint.

(e) LATE BOTTOM-LAND SOILS

Bottom-land soils which occur in the Mississippi bottoms and in the smaller stream valleys of the adjoining bluffs of the deep loess area are mapped as late bottoms.

Brown Silt Loam (1426)

Brown Silt Loam occurs in the Mississippi bottom south of Warsaw. It is formed by deposit from the Mississippi river. It covers an area of 10.88 square miles, or 1.42 percent of the area of the county.

The surface soil is a brown silt loam varying on the one hand to a sandy loam and on the other to a silty clay loam. At a depth of 8 to 12 inches the color begins to change gradually to a drabbish brown and at 20 to 25 inches it becomes a drabbish yellow. As a rule, the texture gradually grows finer with increasing depth. However, there is more variation in the subsoil than in the surface, and not infrequently pure sand is found in the subsoil.

Management.—This type is very fertile. Areas which are protected by levees from all overflow are becoming acid. The only management requirements of this type are limestone where needed, the growth and handling of legumes in such a way as to maintain the nitrogen and organic matter, and good tillage.

Drab Clay (1415)

Drab Clay consists of very fine soil material deposited in what is commonly spoken of as "back-water", where there is very little current. This type covers an area of 7.76 square miles, or about 1 percent of the area of the county.

The surface soil is a drab clay, granular when dry and plastic when wet. It is fairly well supplied with organic matter. It sometimes has a noticeable

amount of sand or gravel. At about 10 inches in depth, the color becomes dark drab with brown mottlings of iron oxide. At a depth of 25 to 30 inches a yellowish tint usually appears.

Management.—In the management of this type, it is very essential that the organic matter be maintained as an aid in keeping the soil in good tilth. It is well to use legumes in so far as is possible as a source of organic matter in order to provide for maintaining the nitrogen supply. About 2 tons of limestone per acre is usually necessary on this type to grow sweet clover.

Brown Sandy Loam (1460)

Considerable Brown Sandy Loam occurs in the northern part of the county as well as in the bottom land south of Warsaw. It comprizes 7.88 square miles, or about 1 percent of the area of the county.

The surface soil is a brown sandy loam varying from light brown to almost black, owing to the varying content of organic matter. It also varies in sand content from a sand to a silt loam and, as a general rule, the sand content varies considerably within small areas. The color gradually becomes a yellowish brown and finally yellow at a depth of about 25 to 30 inches. The texture varies considerably but as a rule becomes a little finer with increasing depth.

Management.—If overflow does not take place in this type, it will be necessary to turn under organic matter and legumes for maintaining the nitrogen supply, as the total amount of this element is not high. Since the soil is somewhat acid, unless subject to overflow, it would be well to apply about 1 ton of limestone per acre to get the best results with legumes, especially with sweet clover.

Mixed Loam (1454)

Mixed loam occurs almost entirely outside of the levee and is of very little agricultural value. The total area covered by this type is 2.36 square miles, or .31 percent of the area of the county. It is a mixture of all sorts of constituents. There are areas that are very sandy, while others may be very heavy. Practically none of it is under cultivation.

Yellow Fine Sandy Loam (1475)

Yellow Fine Sandy Loam is formed by the wash from the deep loess area of the upland adjoining the bottom land. The total area comprizes 3.84 square miles, or .5 percent of the area of the county.

The surface soil is a yellowish to yellow-brown fine sandy loam. It is low in organic matter as indicated by the color. Very little change is discernible with increasing depth except that the yellow color becomes more pronounced.

Management.—This type, tho not high in nitrogen, will grow excellent crops. If overflow is discontinued, it will be necessary to make provision for maintaining or even increasing the supply of nitrogen. This can be done with clover and other legume crops, provided that the larger part of the crop, or the manure produced from it, is turned back into the soil. There is a large amount of limestone present in all strata of the soil and phosphate fertilizers are not needed.

Brown Silt Loam On Sand (1426.2)

Only one area of Brown Silt Loam On Sand was mapped, and that in the southwestern part of the county, just inside the levee in Sections 18 and 19, Township 3 North.

The surface soil is a brown silt loam varying somewhat in sand content, and is fairly well supplied with organic matter. At a depth of about 12 inches, light brown sandy silt loam is encountered and this rests on sand at a depth varying from 16 to 24 inches.

River Sand (1480)

A small area of River Sand, comprizing 205 acres, is found just south of Warsaw. While it is a river deposit, yet it has been reworked to a certain extent by the wind, thru which process some small, low dunes have been formed. It is light brown of yellowish brown sand in the surface and passes into yellow sand at 8 to 12 inches.

Management.—This type is adapted to special crops, such as melons. It usually is not acid. Nitrogen is very deficient and must be supplied by applications of manure or by the turning under of legumes; or in case highly specialized crops are grown, complete commercial fertilizers which are high in nitrogen may be used at a profit.

Drab Clay On Sand (1415.3)

Drab Clay On Sand is found only in the southern part of the Mississippi bottom-land area in Sections 33 and 34, Township 3 North. Doubtless a large part of these bottom lands have sand as the deeper subsoil. In the case of this type, the sand comes near enough to the surface so that it is taken into account in our classification. The total area of this type is 384 acres.

The surface soil is a drab clay, granular when dry, and plastic when wet, resembling the surface of the type, Drab Clay (1415), altho it may contain a larger percentage of sand. It is fairly well supplied with organic matter. Sand is found at 16 to 30 inches in depth.

Management.—The type is well supplied with nitrogen and phosphorus and with the turning under of ordinary residues, the nitrogen and organic matter can be maintained. The soil is slightly acid, and for best results with legumes, especially sweet clover and alfalfa, it may be necessary to apply 1 ton of limestone per acre.

(f) RESIDUAL SOILS

No soil areas have been found that are formed from the decomposition of rocks in place. There are, however, numerous outcrops of limestone in the county containing large numbers of silicious formations such as geodes.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived mainly from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter constitutes the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise types names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE A.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain.....	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay.....	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay.......	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table A shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

SUPPLY OF PLANT-FOOD ELEMENTS

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. Nitrogen, one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1]See footnote to Table A.
[2]Young second year's growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT-FOOD ELEMENTS

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is of value to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. In testing, therefore, the sample should be about as dry as when the soil is in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence, and indicates that the soil contains limestone or some other carbonate. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for fixing atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method

of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate. or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the

phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount

to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant-food elements of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must consider also the loss by leaching.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur

in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too

late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year—Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year—Wheat or oats (with clover)
Third year —Clover
Fourth year—Wheat (with clover)

First year —Corn
Second year—Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year—Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year—Clover
Third year —Corn
Fourth year—Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year—Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year—Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Hancock County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results from certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produeed, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on Brown Silt Loam at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical Brown Silt Loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre.

Table 1 gives the yearly records of the crop yields from the Morrow plots, and Table 2 presents the results in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Annual Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None............	....	....	....	....	....	....
1888	None............	54.3	49.5	....	....	48.6	....
1889	None............	43.2	....	37.4	....	....	(4.04)
1890	None............	48.7	54.3	....	....	....	(1.51)
1891	None............	28.6	33.2	....	....	....	(1.46)
1892	None............	33.1	....	37.2	70.2	....	....
1893	None............	21.7	29.6	....	34.1	....	....
1894	None............	34.8	....	57.2	....	65.1	....
1895	None............	42.2	41.6	....	....	22.2	....
1896	None............	62.3	....	34.5	....	....	....
1897	None............	40.1	47.0	....	....	....	....
1898	None............	18.1	....	....	....	....	....
1899	None............	50.1	44.4	....	53.5	....	....
1900	None............	48.0	....	41.5	....	....	....
1901	None............	23.7	33.7	....	34.3	....	....
1902	None............	60.2	....	56.3	....	54.6	....
1903	None............	26.0	35.9	....	....	....	(1.11)
1904	None............	21.5	....	17.5	55.3	....	....
1904	MLP............	17.1	....	25.3	72.7	....	....
1905	None............	24.8	50.0	....	....	42.3	....
1905	MLP............	31.4	44.9	....	....	50.6	....
1906	None............	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP............	35.8	....	52.4	....	....	(1.74)[1]
1907	None............	29.0	47.8	....	80.5	....	....
1907	MLP............	48.7	87.6	....	93.6	....	....
1908	None............	13.4	....	32.9	....	40.0	....
1908	MLP............	28.0	....	45.0	....	44.4	....
1909	None............	26.6	33.0	....	....	....	(.65)[2]
1909	MLP............	31.6	64.8	....	....	....	(1.73)[3]
1910	None............	35.9	....	33.8	58.6	....	....
1910	MLP............	54.6	....	59.4	83.3	....	....
1911	None............	21.9	28.6	....	....	20.6	....
1911	MLP............	31.5	46.3	....	....	38.0	....
1912	None............	43.2	....	55.0	....	....	16.3[1]
1912	MLP............	64.2	....	81.0	....	....	20.0[1]
1913	None............	19.4	29.2	....	33.8	....	....
1913	MLP............	32.0	25.0	....	47.8	....	....
1914	None............	31.6	....	33.6	....	39.6	....
1914	MLP............	39.4	....	58.2	....	60.4	....
1915	None............	40.0	49.0	....	....	....	24.2[1]
1915	MLP............	66.0	81.2	....	....	....	27.1[1]
1916	None............	11.2	....	37.5	27.8	....	....
1916	MLP............	10.8	....	64.7	40.6	....	....
1917	None............	40.0	48.4	....	....	68.4	....
1917	MLP............	78.0	81.4	....	....	86.9	....
1918	None............	13.6	....	27.2	....	....	(2.58)
1918	MLP............	32.6	....	59.3	....	....	(4.04)
1919	None............	24.0	30.8	....	52.2	....	....
1919	MLP............	43.4	66.2	....	70.8	....	....
1920	None............	28.2	....	37.2	....	52.2	....
1920	MLP............	54.4	....	51.6	....	69.7	....
1921	None............	19.8	30.6	....	....	....	(.26)[4]
1921	MLP............	42.2	68.4	....	....	....	(1.33)[5]
1922	None............	24.6	....	39.3	49.2	....	....
1922	MLP............	39.4	....	55.8	65.3	....	....
1923	None............	15.0	17.2	....	....	53.4	....
1923	MLP............	31.4	46.4	....	....	66.6	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		20 crops	*10 crops*	*10 crops*	*7 crops*	*7 crops*	*4 crops*
1904 to 1923	None........	25.5	36.5	34.9	51.1	45.2	(1.23)[1]
	MLP........	40.6	61.2	55.3	67.7	59.5	(2.21)[1]

[1]One crop of soybean hay included.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K**) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this ''extra heavy'' treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in the corresponding Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, manure has been decidedly more effective than residues in corn and wheat, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact during the thirteen years there were five clover failures, when soybeans were substituted. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to de-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

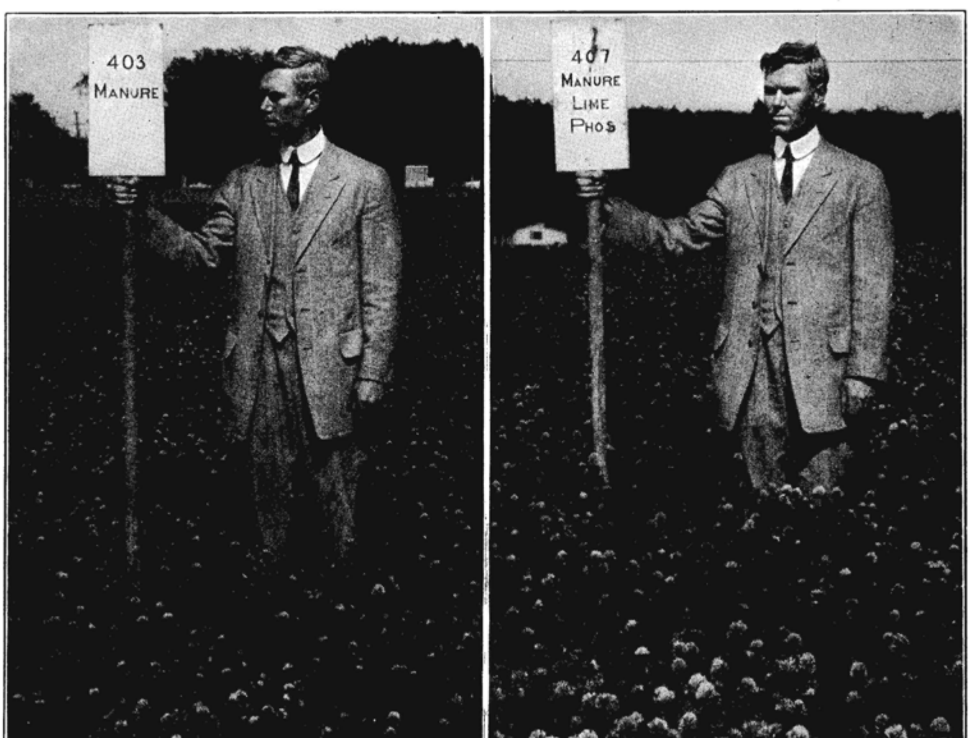
Average Annual Yields 1911-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *13 crops*	Oats *13 crops*	Wheat *13 crops*	Clover or Soybeans: Clover[1] *8 crops*	Clover or Soybeans: Soybeans[2] *5 crops*	Alfalfa *13 crops*
1	0	54.3	52.3	25.8	(2.10)	(1.47)	(2.44)
2	R	55.1	53.6	28.5	1.38	19.8	(2.55)
3	M	65.5	64.4	28.9	(2.29)	(1.62)	(2.50)
4	RL	63.8	56.4	31.6	1.58	20.3	(2.76)
5	ML	69.3	64.8	34.2	(2.69)	(1.67)	(2.99)
6	RLP	70.6	69.7	42.0	1 72	23.5	(3.78)
7	MLP	71.6	69.2	40.9	(3.31)	(1.97)	(3.87)
8	RLPK	70.8	72.0	39.7	1.35	25.5	(3.97)
9	MLPK	69.6	71.5	40.0	(3.32)	(2.20)	(3.89)
10	Mx5LPx5	65.3	71.0	40.0	(2.85)	(2.22)	(3.94)

[1]In addition to the clover seed a crop of hay was taken from Plots 2, 4, 6, and 8 in the year 1918 and again in 1921, producing yields which, reduced to an eight-year average, amount to .40, .45, .50, and .50 tons respectively.
[2]Soybeans substituted when clover failed.

pends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The



Manure — Yield: 1.43 tons per acre

Manure, limestone, phosphorus — Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 16.2 bushels of wheat, over the yield of the untreated land, has been obtained as a thirteen-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others so that on the whole potassium treatment has not been effective on these plots.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn and clover yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be re-

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields 1908-1919—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn[3] *9 crops*	Oats[3] *9 crops*	Wheat[3] *8 crops*	Clover[4] *3 crops*	Soybeans *7 crops*
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(2.31)	(1.28)
MLP	64.1	59.6	43.9	(2.82)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Oats *9 crops*	Clover *5 crops*	Soybeans *4 crops*
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Corn 3d year *9 crops*		Soybeans *9 crops*
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

garded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned as high yields as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is relatively little difference between the effect of manure and of residues.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The com-

parison may be somewhat impaired, however, by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are of especial interest because this element has been applied on this field solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphate has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records from this field furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

TABLE 5. COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures..............	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus...	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The Carthage Field

An experiment field on Brown Silt Loam is located in Hancock county just south of Carthage. This field has been in operation since 1911. The diagram presented as Fig. 4 shows the arrangement of plots on the Carthage field. There are two systems of plots representing two separate crop rotations designated as the major and minor rotations. The first system comprizes four series (numbered 100-200-300-400) made up of 10 plots each, and the rotation is wheat, corn, oats, and clover. The yields of all crops grown in this rotation each year since the beginning of the experiments are recorded in Table 6. The results are summarized in Table 7 where the average annual yields are shown for each plot covering the years that full treatment has been in effect. For the present purpose only the grain crops are considered in this summary. The lower section of this table gives a more condensed summary which affords some interesting comparisons. Here the results from the corresponding plots of the live-stock and the grain system are so combined as to bring out the effect of organic manures alone, organic manures in combination with limestone, and organic manures in combination with limestone and phosphorus.

In looking over these results, attention is first called to the beneficial effect of organic manures, whether applied in the form of animal manure or plant

manures (crop residues and legumes turned under). This suggests the importance of carefully conserving and regularly applying all available stable manure. If stable manure is not available in sufficient quantity, then, as these results demonstrate, the necessary organic matter can be supplied by returning to the land all unused crop residues and plowing under legumes as green manure.

The results also bring out the beneficial effect of limestone on this soil, all crops showing in the general averages an increase in yield where limestone has been applied.

Taking into account the variations exhibited by the untreated check plots, it seems doubtful whether the small gains appearing as the effect of rock phosphate as used on this field are really significant. At any rate the small gains thus far secured would not be sufficient to cover the cost of the material.

For the effect of the potassium treatment we may compare Plots 8 and 9. Here again there has been no significant response to the treatment unless it be in the case of the wheat crop, where the averages show an increase of 3 bushels per acre for Plot 9 over Plot 8. From the standpoint of economic practice, however, this increase would scarcely justify a recommendation for the general use of potassium in this system of farming.

The minor rotation (series 500-600-700) on the Carthage field is given over to an experiment to determine the effects of different amounts of rock phosphate applied with and without gypsum. This work has scarcely been under way long enough to warrant conclusions and, as a matter of fact, very little effect of the treatments are to be seen as yet. However, since the field is located in Hancock county and should, therefore, be of especial interest in this report, it is the purpose to place on record here all the results on the Carthage field to date. The data for this minor rotation together with a description of the treatments and the arrangement of the plots are shown in Table 8. About the only noticeable effect of the treatments to be observed is a rather consistent tendency toward a depression on the gypsum plots in the year 1923. Judgment, however, must be withheld for the accumulation of further data.

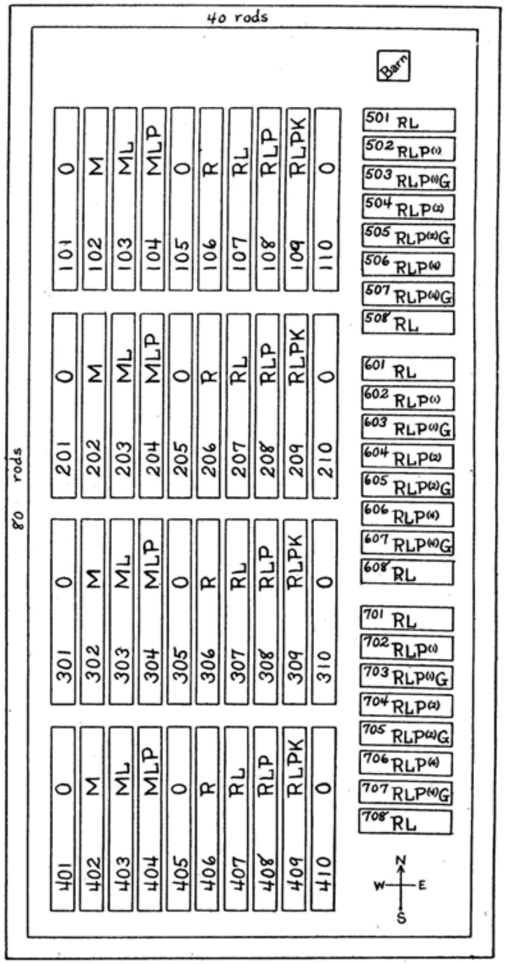


FIG. 4.—DIAGRAM OF CARTHAGE EXPERIMENT FIELD

Table 6.—CARTHAGE FIELD: Brown Silt Loam, Prairie; Upper Illinoisan Glaciation
Rotation: Wheat, Corn, Oats, Clover

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1911 Corn[1]	1912 Oats[2]	1913 Clover[5]	1914 Wheat[6]	1915 Corn	1916 Oats	1917 Clover	1918 Wheat	1919 Corn	1920 Oats	1921 Clover	1922 Wheat	1923 Corn
101	0	39.4	31.4	(2.46)	18.8	35.9	20.3	(2.68)	17.1	34.4	33.3	(1.12)	20.7	41.9
102	M	43.7	33.9	(2.64)	19.2	43.0	31.2	(2.53)	28.6	42.3	36.6	(1.33)	22.1	64.7
103	ML	38.5	33.3	(3.06)	22.9	40.0	32.8	(2.37)	37.6	51.6	42.0	(1.95)	26.6	75.4
104	MLP	41.0	37.0	(3.02)	23.6	47.0	35.9	(2.54)	42.0	63.7	48.1	(2.17)	27.7	74.6
105	0	35.0	30.2	.67	25.6	23.1	23.4	.67	31.8	40.5	35.2	1.33	18.5	52.4
106	R	30.7	24.4	.67	24.7	23.4	25.0	.67	35.2	51.4	28.9	1.55	22.0	60.7
107	RL	31.6	26.1	.50	25.0	37.0	29.7	.58	39.1	59.5	46.4	2.41	26.8	69.0
108	RLP	31.2	26.3	.50	27.7	45.0	34.4	1.08	44.8	61.1	43.8	2.42	28.2	69.9
109	RLPK	32.0	26.1	.50	28.3	47.6	40.6	.92	45.9	57.9	44.5	2.39	28.7	73.0
110	0	36.5	31.4	(3.64)	28.4	24.2	21.9	(2.00)	31.6	42.9	32.8	1.45	20.1	53.1
		Wheat[7]	Corn[3]	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Soybeans	Wheat
201	0	4.3	33.3	27.2	(1.14)	24.0	23.5	49.7	(2.60)	31.9	36.9	28.1	18.8	14.8
202	M	4.9	38.8	30.0	(1.25)	26.7	27.9	51.7	(2.42)	30.8	40.6	35.2	18.3	21.2
203	ML	3.8	39.7	32.0	(1.52)	28.7	32.9	57.8	(2.45)	30.8	48.3	45.8	19.8	28.6
204	MLP	4.7	40.8	33.9	(1.66)	30.1	29.1	66.9	(2.16)	30.8	51.2	48.3	15.8	30.8
205	0	4.5	30.4	26.7	1.42	24.0	23.2	56.4	.17	31.8	43.7	32.0	14.2	17.6
206	R	4.4	42.3	22.5	1.42	30.8	23.4	67.0	.17	25.1	43.7	37.5	19.8	20.8
207	RL	5.0	41.3	24.4	1.33	34.2	29.9	72.0	.50	23.5	57.3	43.8	8.7	34.8
208	RLP	5.4	55.4	27.5	1.50	38.0	27.6	66.1	1.83	24.5	49.3	45.3	8.8	34.7
209	RLPK	5.3	57.2	26.9	1.08	38.8	31.7	64.1	1.33	25.5	52.0	40.2	11.8	35.5
210	0	4.5	28.2	25.0	(1.88)	31.2	20.6	40.9	(2.41)	21.2	38.9	27.3	21.4	20.5

TABLE 6.—CARTHAGE FIELD: *Concluded*

Plot No.	Soil treatment applied	1911 Soybeans[1]	1912 Wheat[4]	1913 Corn	1914 Oats	1915 Soybeans	1916 Wheat	1917 Corn	1918 Oats	1919 Soybeans	1920 Wheat	1921 Corn	1922 Oats	1923 Soybeans
301	0..........	11.0	7.4	25.3	18.0	(2.40)	7.2	22.1	37.3	(1.78)	30.6	39.9	37.8	31.2
302	M..........	10.3	3.6	26.1	15.6	(2.90)	12.5	26.5	38.8	(1.97)	32.3	39.3	45.2	27.1
303	ML........	9.3	3.8	23.7	17.2	(2.99)	16.7	36.2	35.9	(1.68)	39.3	54.6	51.1	30.4
304	MLP.......	11.3	5.3	34.8	17.0	(3.11)	22.5	41.4	35.3	(1.66)	41.1	57.6	53.8	28.8
305	0..........	10.8	5.7	28.6	17.8	19.2	7.5	17.4	30.3	16.6	18.4	19.4	35.9	23.6
306	R..........	10.8	4.3	47.8	23.4	21.7	8.3	54.2	43.0	19.5	18.7	49.4	46.1	24.3
307	RL........	11.5	6.8	49.7	26.6	23.3	18.8	61.9	49.4	22.2	36.8	54.5	57.0	29.7
308	RLP.......	10.3	5.5	49.1	23.6	29.7	20.0	67.8	69.7	21.5	32.1	53.6	53.9	28.2
309	RLPK	10.7	7.1	51.3	24.2	26.7	25.0	66.1	53.8	22.8	41.6	57.9	54.4	29.2
310	0..........	10.2	6.5	29.2	19.2	(2.39)	10.8	37.0	32.2	(1.59)	27.3	35.5	40.0	22.8
		Oats[1]	Soybeans[2]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats
401	0..........	12.7	20.6	24.0	24.6	30.6	(2.23)	18.8	32.4	37.8	(2.37)	24.8	58.1	45.3
402	M..........	10.6	17.9	29.8	39.5	37.8	(1.88)	19.2	38.4	38.0	(2.47)	33.8	65.9	52.7
403	ML........	14.8	19.6	29.1	40.8	48.4	(2.18)	18.9	52.8	41.2	(2.73)	34.5	71.3	60.2
404	MLP	15.5	20.4	24.2	44.7	49.7	(2.72)	17.5	53.5	45.3	(2.69)	33.8	76.9	59.7
405	0..........	12.8	16.9	21.0	26.4	30.3	.08	16.7	34.7	40.2	(1.51) 2.32	24.3	57.5	41.3
406	R..........	9.8	15.0	16.4	35.4	35.9	.17	18.9	36.0	43.6	(1.73) 1.98	20.3	64.2	38.0
407	RL........	13.3	14.6	24.2	47.2	54.7	.08	21.7	33.3	40.0	(1.21) 2.02	31.5	79.9	51.3
408	RLP.......	10.3	16.5	23.2	57.2	60.3	.17	15.2	47.3	45.3	(1.89) 2.05	35.3	78.4	55.8
409	RLPK	11.3	16.3	23.2	58.3	59.4	.50	24.1	44.9	46.6	(1.71) 1.82	34.8	82.2	63.8
410	0..........	10.9	17.0	22.7	31.3	28.1	(2.44)	16.0	37.3	37.7	(2.80)	23.8	62.5	39.5

[1]No soil treatment. [2]Residues only. [3]No lime. [4]No manure or lime. [5]No manure, phosphate, or potassium. [6]No manure. [7]Phosphorus and potassium only.

TABLE 7.—CARTHAGE FIELD: GENERAL SUMMARY OF THE GRAIN CROPS
Average Annual Yields, 1913-1923—Bushels per acre

Serial plot No.	Soil treatment applied	Wheat *9 crops*	Corn *11 crops*	Oats *11 crops*
1	0	21.1	34.1	33.2
2	M	25.2	41.3	37.5
3	ML	29.1	48.0	42.2
4	MLP	30.6	52.2	44.9
5	0	21.2	33.4	33.6
6	R	22.2	44.5	37.4
7	RL	29.7	52.7	45.0
8	RLP	30.3	55.1	47.8
9	RLPK	33.3	56.6	47.1
10	0	22.5	37.5	31.3
1 5 10	0 0 0	21.6	35.0	32.7
2 6	M R	23.7	42.9	37.5
3 7	ML RL	29.4	50.4	43.6
4 8	MLP RLP	30.5	53.7	46.4

TABLE 8.—CARTHAGE FIELD: ROCK PHOSPHATE AND GYPSUM EXPERIMENT
ROTATION: CORN, CORN, OATS (WITH SWEET CLOVER)

Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1920	1921	1922		1923	
		Corn	Oats	Corn		Corn	
501	RL	31.8	23.8	68.0		70.0	
502	RL + 100 lbs. Rock phos.	51.8	29.8	71.4		74.8	
503	RL + 100 lbs. Rock phos. + 100 lbs. Gypsum	48.6	29.4	72.0		71.6	
504	RL + 200 lbs. Rock phos.	61.2	29.7	74.8		75.8	
505	RL + 200 lbs. Rock phos. + 200 lbs. Gypsum	60.6	31.2	72.6		70.6	
506	RL + 400 lbs. Rock phos.	68.0	30.9	74.4		89.0	
507	RL + 400 lbs. Rock phos. + 400 lbs. Gypsum	66.8	32.5	73.6		61.2	
508	RL	67.0	32.2	72.4		76.8	
		Corn	Corn	Oats	Clover	Corn	
601	RL	68.4	60.6	43.8	(.93)	76.4	
602	RL + 100 lbs. Rock phos.	68.6	73.8	40.3	(1.08)	74.2	
603	RL + 100 lbs. Rock phos. + 100 lbs. Gypsum	63.6	58.2	43.8	(1.30)	71.6	
604	RL + 200 lbs. Rock phos.	63.6	67.8	43.4	(1.10)	75.4	
605	RL + 200 lbs. Rock phos. + 200 lbs. Gypsum	62.4	72.0	40.6	(1.00)	70.8	
606	RL + 400 lbs. Rock phos.	58.4	67.0	44.7	(1.08)	72.2	
607	RL + 400 lbs. Rock phos. + 400 lbs. Gypsum	68.6	71.4	43.4	(.98)	68.8	
608	RL	70.8	64.2	44.1	(.98)	72.6	
		Oats	Corn	Corn		Oats	Clover
701	RL	45.6	61.8	53.4		50.6	(1.39)
702	RL + 100 lbs. Rock phos.	31.2	71.0	52.6		53.2	(1.25)
703	RL + 100 lbs. Rock phos. + 100 lbs. Gypsum	61.6	64.6	58.8		51.9	(1.31)
704	RL + 200 lbs. Rock phos.	39.7	62.4	50.2		46.3	(1.27)
705	RL + 200 lbs. Rock phos. + 200 lbs. Gypsum	48.1	60.8	54.4		38.1	(1.07)
706	RL + 400 lbs. Rock phos.	40.3	61.6	63.4		44.1	(1.30)
707	RL + 400 lbs. Rock phos. + 400 lbs. Gypsum	42.5	57.2	57.4		45.9	(1.22)
708	RL	38.8	59.6	60.0		47.5	(1.40)

The Clayton Field

Another experiment field representing Brown Silt Loam is located in Adams county just south of Clayton. This field has been under way since 1911. The crop rotation consists of wheat, corn, oats, and clover. Soybeans have been substituted several times for the clover when the latter failed. Table 9 shows a summary of the results in the form of the average annual yields of the respective grain crops.

TABLE 9.—CLAYTON FIELD: BROWN SILT LOAM, PRAIRIE; UPPER ILLINOISAN GLACIATION
Average Annual Yields of Grain Crops, 1913-1923—Bushels per acre

Serial plot No.	Soil treatment applied	Wheat *9 crops*	Corn *11 crops*	Oats *11 crops*
1	0	17.4	31.2	36.1
2	M	21.6	47.5	43.7
3	ML	23.6	53.2	44.4
4	MLP	26.7	52.4	46.5
5	0	17.1	33.4	38.0
6	R	20.8	45.1	40.5
7	RL	23.5	53.6	48.5
8	RLP	27.3	53.8	51.5
9	RLPK	27.5	58.2	51.6
10	0	18.3	35.0	40.4
1 5 10	0 0 0	17.6	33.2	38.2
2 6	M R	21.4	46.3	42.1
3 7	ML RL	23.6	53.4	46.5
4 8	MLP RLP	27.0	53.1	49.0

Combining the results of the corresponding plots of the grain system and the live-stock systems as shown in the lower section of Table 9, we have some interesting comparisons. The beneficial effect of organic manures is very apparent whether they are applied in the form of animal manure or of plant manures. All crops likewise show an increase for limestone applied with the organic manures. The use of rock phosphate applied with organic manures and limestone has produced still further increase for wheat, but not for corn, and the effect on the oats is doubtful in view of the wide variation in check plots. Potassium salts appear to have benefited the corn, but not the wheat and oats, altho the increase in corn yield would not pay for the cost of the treatment.

The Bloomington Field

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has

only a single series of plots so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat, and, since 1905, they have been grown in the sequence named.

On account of irregularities in the land, results from Plots 1 and 10 are not considered altogether reliable; therefore, they are not included in the figures presented. Since these are the only unlimed plots no conclusions can be drawn regarding the action of limestone on this field.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field has always been applied in the form of steamed bone meal and at the rate of 200 pounds per acre per year.

Table 10 presents a summary of the work by annual average yields for the corn, oats, and wheat crops. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they have been applied.

As might be expected the "residues" treatment, supplying organic matter and nitrogen, shows a beneficial effect. It is of interest to note that the effect of the residues is greater on the phosphorus plots than on those not receiving phosphorus.

The outstanding feature of the results on the Bloomington field is the effect of phosphorus, as applied in the form of bone meal. In every crop on every plot where bone meal has been applied there is a remarkable response to the

TABLE 10.—BLOOMINGTON FIELD: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields of Grain Crops, 1902-1923—Bushels per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*
2	L	41.5	44.7	24.1
3	LR	47.5	46.2	27.9
4	LP	55.8	54.3	45.7
5	LK	46.2	43.5	25.5
6	LRP	60.6	66.0	49.7
7	LRK	48.6	46.8	27.5
8	LPK	60.9	57.2	44.5
9	LRPK	64.2	63.1	50.4

Increases—Bushels per acre

		Corn	Oats	Wheat
	For Residues			
	LR over L	6.0	1.5	3.8
	LRP " LP	4.8	11.7	4.0
	LRK " LK	2.4	3.3	2.0
	LRPK " LPK	3.3	5.9	5.9
	For Phosphorus			
	LP over L	14.3	9.6	21.6
	LRP " LR	13.1	19.8	21.8
	LPK " LK	14.7	13.7	19.0
	LRPK " LRK	15.6	16.3	22.9
	For Potassium			
	LK over L	4.7	−1.2	1.4
	LRK " LR	1.1	.6	−.4
	LPK " LP	5.1	2.9	−1.2
	LRPK " LRP	3.6	−2.9	.7

treatment as shown by the increases in yield. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues and phosphorus) we find the phosphorus treatment has produced an average increase in the yield of corn of about 13 bushels per acre, while the yield of oats has been increased by about 20 bushels and that of wheat by about 22 bushels per acre. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8 where potassium instead of residues is present.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is distinctly a limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit. It is of extreme interest to know whether a similar response would follow the use of other phosphorus carriers such as rock phosphate and acid phosphate and experiments are now under way designed to answer this question.

Quite different are the results from the use of potassium on this field. The potassium has been applied mainly in the form of potassium sulfate, but in 1917, when this material became unavailable thru war conditions, potassium carbonate was substituted. There is a moderate increase in the corn yield where potassium has been used and particularly where residues are absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

YELLOW-GRAY SILT LOAM

The type Yellow-Gray Silt Loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this variation it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre but after 1911 the use of commercial nitrogen was discontinued and crop residues were substituted. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; and since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 11 presents, in summarized form, the results of the grain crops from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has been, on the whole, ineffective. Also, the

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 5.—CLOVER IN 1913 ON ANTIOCH FIELD

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 12.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when

TABLE 11.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields of Grain Crops, 1902-1923—Bushels or (tons) per acre

Plot No.	Soil treatment applied	Corn *9 crops*	Oats *5 crops*	Wheat *5 crops*
1	0	24.5	32.3	14.7
2	L	21.8	26.8	13.3
3	LR	22.5	29.9	18.9
4	LP	31.0	43.6	35.0
5	LK	23.3	27.8	17.8
6	LRP	34.1	43.3	32.6
7	LRK	25.4	26.9	19.2
8	LPK	26.1	38.2	30.3
9	LRPK	38.9	42.6	28.1
10	RPK	38.7	44.7	31.0

TABLE 12.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields of Grain Crops, 1911-1923
Bushels or (tons) per acre

Plot No.	Soil treatment applied	Corn *13 crops*	Oats *13 crops*	Wheat *9 crops*
1	0	16.6	9.6	5.7
2	M	29.7	11.8	7.2
3	ML	43.3	19.6	18.9
4	MLP	44.1	20.0	19.9
5	0	17.7	9.5	6.4
6	R	20.9	11.8	8.0
7	RL	36.8	21.1	17.9
8	RLP	39.4	22.4	19.7
9	RLPK	45.8	22.8	22.2
10	0	20.5	10.8	5.9

limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus is applied here in the form of rock phosphate, which thus far has given only moderate returns in increased crop yields.

Potassium as applied with residues, lime, and phosphorus seems to be of some benefit for both corn and wheat.

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

In accounting for the difference in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth. In view of these variations, a general recommendation for lime treatment, that will apply to all localities on Yellow-Gray Silt Loam cannot be given out until more information is acquired. Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on pages 32 and 33 of the Appendix.

Phosphorus, as applied in bone meal, has paid well on the Antioch field, but, as applied in rock phosphate on the Raleigh field, has failed thus far to return the cost of the material. This must not be construed as a comparison between bone meal and rock phosphate as carriers of phosphorus, for these results do not furnish such a comparison. With the information at hand no definite recommendation concerning the application of phosphorus that will apply to this soil type as a whole can be given at present. It is suggested, however, that each farmer might well try out phosphorus on his own land on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time may not be far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

Because such a large proportion of the area of Hancock county is made up of Yellow Silt Loam it is believed that on account of some experiments on the Vienna field, the single representative of this type of soil, will be of interest here.

FIG. 7.—VIEW OF UNIMPROVED HILLSIDE LAND TAKEN JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 8

The Vienna Field

In 1906 the University acquired a sixteen-acre tract of land representative of Yellow Silt Loam near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without doing much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall if the water breaks over it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure per acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

FIG. 8.—CORN CROP ON THE VIENNA EXPERIMENT FIELD GROWING ON IMPROVED HILLSIDE LAND THAT HAD BEEN FORMERLY BADLY ERODED. COMPARE WITH FIG. 7

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

Table 13 contains a summarized statement of the results obtained.

TABLE 13.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(0.68)
B	Embankments and hillside ditches	32.4	12.7	(0.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(0.80)
D	Check	14.1	4.6	(0.21)

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 7 and 8 will serve to indicate the possibility of improving this type of soil.

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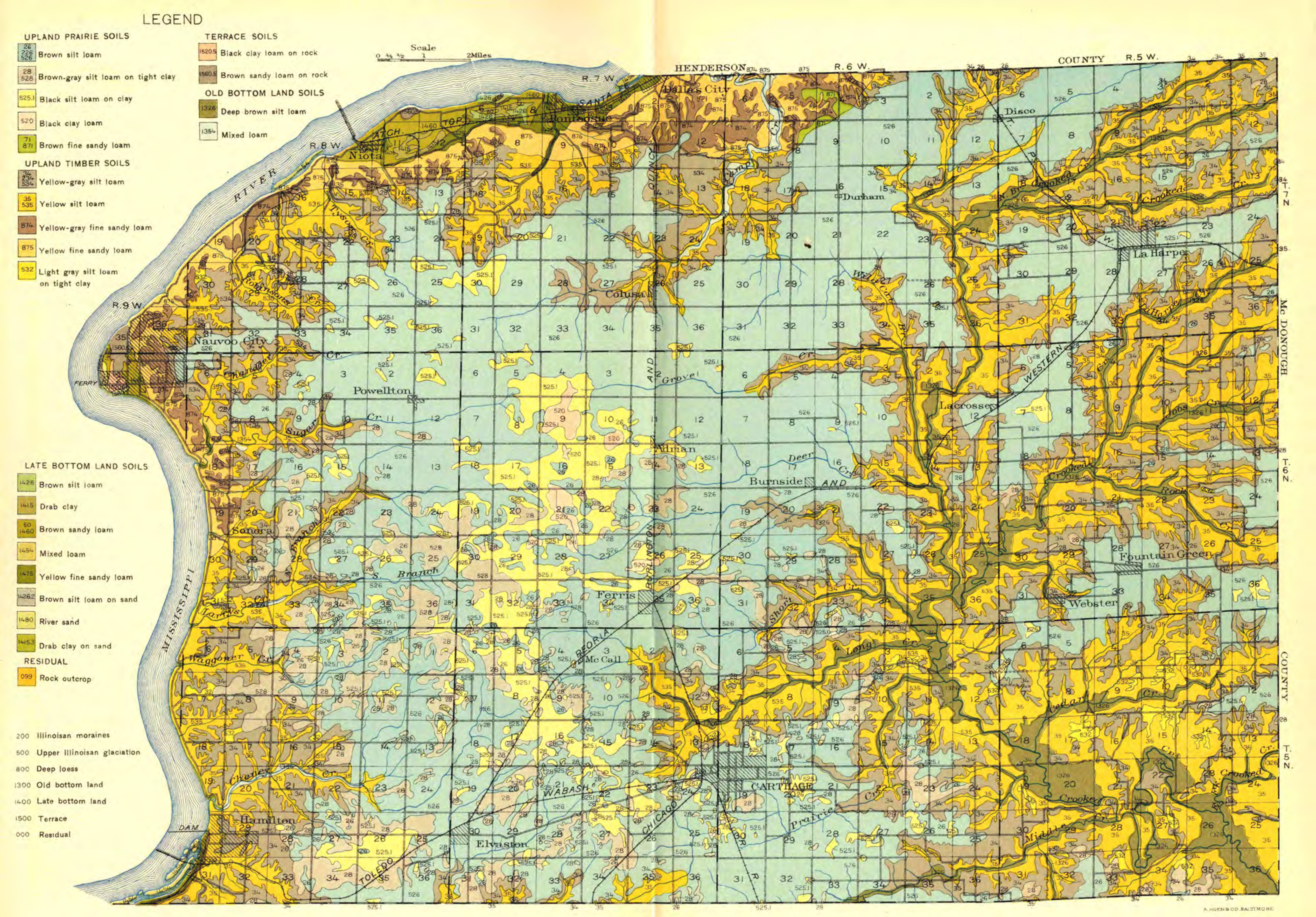
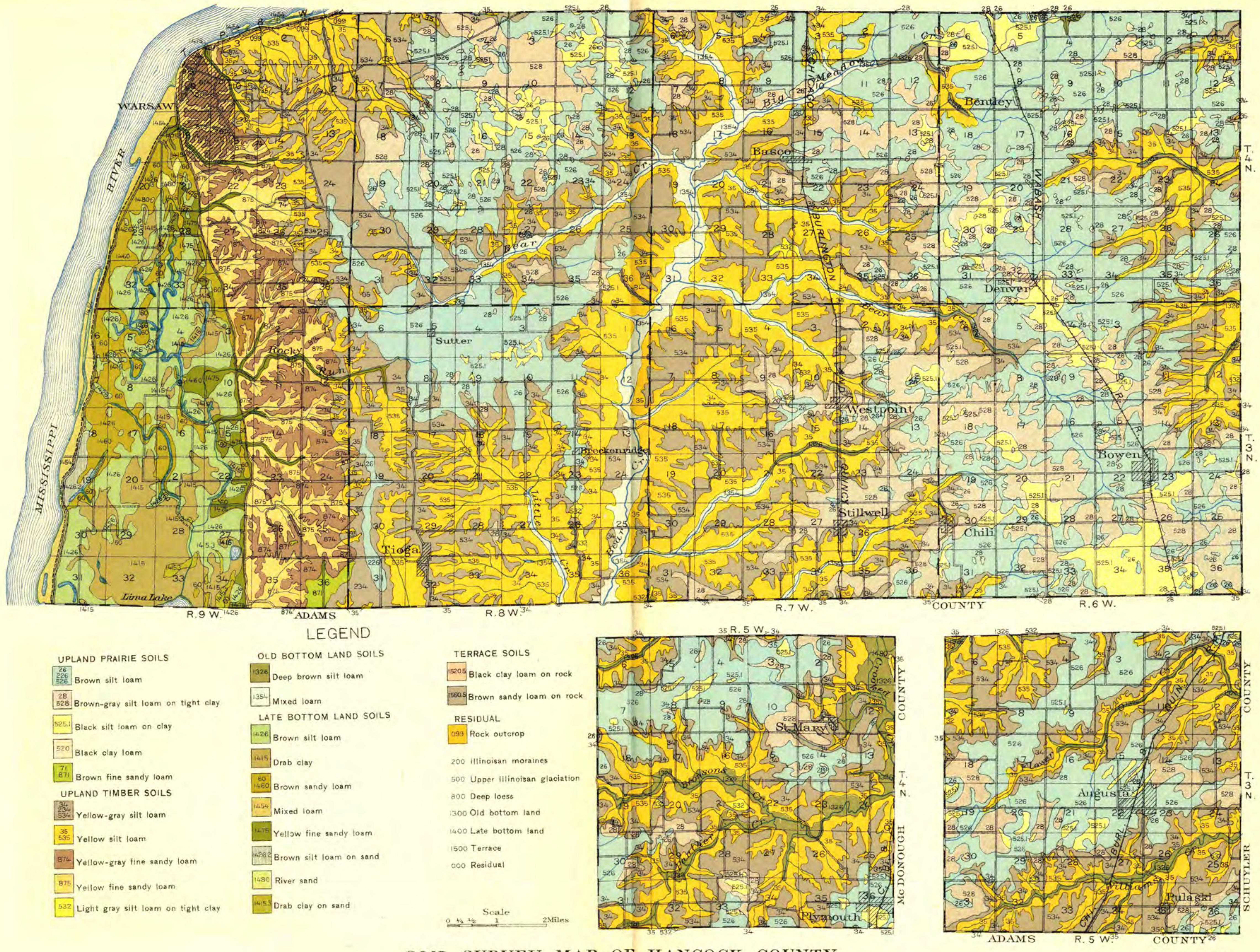


SOIL SURVEY MAP OF HANCOCK COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION



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